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Determination of Drought Tolerance of Chickpea and Lentil Plants, and Structural Elements of their Varieties

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Water retention capability of leaves in chickpea and lentil varieties, temperature of the sowing surface and structural elements of the production have been studied. A direct relationship was found among productivity, the number of beans and the grain number per plant in chickpea varieties. A positive correlation was also observed between productivity and the number of grains per plant in lentil varieties. As a result of the research, varieties relatively tolerant to drought were chosen.

Keywords: *Chickpea, lentil, leaf water retention capability, production index, productivity*

INTRODUCTION

Plants are exposed to stress factors worldwide due to the global climate change and shortage of irrigation water. The enhancement of the ambient temperature and deficiency in irrigation water are main ecological factors limiting plant productivity in arid regions (Bedenko, 1980). Drought having a significant impact on plant development and growth, causes chlorophyll distruction, lipid peroxidation, accumulation of hydrogen peroxide, which leads to the cell membrane damage, increases in ascorbic acid and proline contents (Mukherjee et al., 1983; Aetinkut et al., 2001), stomatal closure, reducing rates of transpiration and photosynthesis and lowered water potential in plant tissues (Yordonov et al., 2003; Gunes et al. 2008).

Generally, plants with high leaf water retention capability are more tolerant to drought (Gunes et al., 2008). Drought tolerance is stipulated by functional stability of the cell structure, high water potential of tissues and adaptive properties of the stem, leaves and generative organs, which allows plants to maintain their growth, development and reduce production loss.

A little-time consuming, simple devices and express-methods have been used in the recent studies of plant drought tolerance. Leaf water retention capability was determined using “Turgomer-1” (Kushnirenko, 1991), temperature changes at the sowing level at the expense of leaf transpiration were measured using the infrared thermometer.

Using these methods, leaf drought tolerance was studied in wheat (Abdulbagiyeva et al., 2007) and field bindweed (Aetinkut et al., 2001) and drought tolerant varieties were chosen.

MATERIALS AND METHODS

To determine plant drought tolerance, measurements were conducted on 12 chickpea and 15 lentil varieties under field conditions. Experiments were performed at the subsidiary experimental field of the Research Institute of Crop Husbandry.

Turgometric measurements were conducted on leaves of intact plants for establishing leaf water retention capability. Then the leaves were excised and turgometric measurements were conducted after 4 hours in four replicates.

Over the past 4 hours, a lot of water exited the leaves via transpiration. Leaf water retention capability was calculated as the ratio T_2/T_1, where T_1 is the result of the first and T_2 the second measurement.

RESULTS AND DISCUSSION

The results of the measurements carried out on chickpea varieties are shown in Table 1. Higher values of the ratio T_2/T_1 corresponds to better water retention capability.

As seen in Table 1, the T_2/T_1 ratio ranged from 0.56 to 0.71. The minimum leaf water retention capability was observed in the variety F.08-116. Higher leaf water retention capability was detected in the F.08-89, Sultan and Sechma L. varieties. The highest value of this paramter -0.71- was found in F.08-89. When temperature of the soil surface was 28.7°C, temperature of the sowing surface changed from 18.2°C to 22.5°C due to transpiration. In the F.08-89 variety having the highest water retention capability and in Sechma L. this parameter was found to be 22.5°C and 22.3°C, respectively.

The leaves of these varieties are also distinguished by more water use efficiency. Moreover, Sechma L. was found to be high productive.

The results of the measurements conducted on lentil varieties are presented in Table 2. In the lentil varieties the T_2/T_1 ratio was found to range from 0.52 to 0.68. The lower values of the T_2/T_1 ratios were observed in the lentil varieties, confirming higher leaf water retention capability of the chickpea varieties. The higher values of the ratio in the chickpea varieties prove that they are more tolerant to drought compared with the lentil varieties. Another distinguishing feature of the chickpea varieties is hairs covering leaves and stems. These hairs preventing transpiration of water, participate also in the reflection of solar radiation and thereby create conditions for drought tolerance.

The lowest T_2/T_1 ratio was observed for the F.2013-4 variety (0.52) and the highest for F.2014-006 (0.68). Considering the T_2/T_1 ratio and temperature indices, the lentil varieties F.2013-18 and F.2014-006 are more tolerant to drought than other varieties.

To determine structural elements of the production and productivity, samples were taken from the same field. 10 chickpea and 10 lentil varieties were used as the study objects.

Table 1. Turgometric and temperature indices of chickpea varieties.

No	Variety	T_1	T_2	T_2/T_1	Temperature, ℃
1	F.07-289	18.3 ± 0.89	11.9 ± 0.93	0.65	21.8 ± 0.94
2	Sanford	22.9 ± 0.71	14.1 ± 0.75	0.62	21.1 ± 0.34
3	F.07-274	21.6 ± 0.48	13.3 ± 0.26	0.62	20.7 ± 0.66
4	Jamila	24.3 ± 0.23	15.4 ± 0.80	0.63	18.2 ± 0.10
5	F.08-89	19.5 ± 0.58	13.9 ± 0.76	0.71	22.3 ± 0.77
6	F.08-196	21.2 ± 0.37	13.3 ± 0.19	0.63	21.7 ± 0.37
7	F.08-116	19.7 ±0.74	11.0 ± 0.22	0.56	22.2 ± 0.50
8	Nazrin	19.3 ± 0.59	12.4 ± 0.83	0.64	21.6 ± 0.25
9	Sultan 2	15.9 ± 0.85	9.4 ± 0.6	0.59	21.3 ± 1.01
10	Sultan	22.6 ± 0.76	15.4 ± 0.14	0.68	21.2 ± 0.43
11	Narmin	24.6 ± 0.21	16.0 ± 0.76	0.65	20.5 ± 0.38
12	Sechma L.	23.6 ± 0.39	16.1 ± 0.05	0.68	22.3 ± 0.10

Table 2. Turgometric and temperature indices of lentil varieties.

No	Varieties	T_1	T_2	T_2/T_1	Temperature, ℃
1	F.86-16 L.	17.7 ± 0.44	10.5 ± 0.61	0.59	20.5 ± 0.07
2	LC00600296	15.4 ± 0.25	8.1 ± 0.31	0.53	20.1 ± 0.60
3	F.2013-22	16.8 ± 0.65	10.3 ± 0.50	0.61	21.5 ± 0.17
4	F.2014-026	13.4 ± 0.49	7.3 ± 0.39	0.54	19.9 ± 0.34
5	F.2013-18	12.6 ± 0.37	8.5 ± 0.57	0.67	21.4 ± 0.34
6	F.2013-4	17.6 ± 0.60	9.2 ± 0.86	0.52	20.9 ± 0.70
7	F.2012-8	16.8 ± 0.19	10.3 ± 0.16	0.61	20.9 ± 0.65
8	F.2013-26	16.6 ± 0.71	10.5 ± 0.64	0.63	20.2 ± 0.34
9	Surian Loc.L.	16.8 ± 0.35	11.2 ± 0.91	0.67	19.8 ± 0.41
10	Arzu	18.4 ± 0.13	12.3 ± 0.56	0.67	19.4 ± 0.37
11	F.2014-006	16.6 ± 0.96	12.7 ± 0.83	0.68	21.2 ± 0.35
12	F.2012-1 L.	17.4 ± 0.77	10.6 ± 0.84	0.61	22.3 ± 0.27
13	F.2013-29	16.1 ± 0.47	9.1 ± 0.37	0.56	23.0 ± 0.69
14	F.2012-18	16.5 ± 0.28	8.1 ± 0.06	0.49	20.0 ± 0.28
15	F.2014-009	19.2 ± 0.78	11.1 ± 0.41	0.58	19.5 ± 0.52

Table 3. Structural elements of the production in chickpea varieties.

No	Varieties	Plant height, (cm)	Height of the first bean above the ground, (cm)	Number of beans	Number of grains per plant	100-grain mass, (gr)	Production index	Productivity, (cwt/ha)
1	Sechma L.	65.5±5.2	34.9±4.4	47.4±6.6	55.5±5.3	35.6	0.46	28.5
2	Narmin	69.8±4.2	41.3±4.2	48.6±3.3	49.9±3.43	32.5	0.41	24.7
3	Sultan-2	72.5±0.2	42.9±1.7	28.3±0.7	29.0±0.7	44.0	0.37	23.2
4	Nazrin	68.4±5.3	44.6±3.2	18.9±1.31	19.4±1.1	41.2	0.38	22.7
5	Jamila	64.6±3.5	34.1±1.7	41.7±3.8	44.2±4.6	44.6	0.42	15.7
6	F-08-116	67.8±5.0	38.1±1.6	30.1±1.8	32.0±3.4	43.7	0.41	21.2
7	F-08-196	58.5±0.6	36.6±1.0	17.6±1.3	18.2±1.4	44.9	0.42	19.4
8	F-08-89	48.6±1.3	31.3±2.3	15.3±0.8	15.6±0.1	42.3	0.35	19.0
9	Sanford	50.9±4.2	33.5±1.0	15.7±0.4	21.4±0.9	38.4	0.37	13.9
10	Sultan (st)	57.5±4.0	34.9±3.5	16.0±1.8	16.8±0.9	35.4	0.39	23.3

One of the main economically important indices of chickpea is plant height. As tall plants grow, the distance between rows becomes smaller, preventing weed development and at the same time the shade maintains moisture of the soil. The height of the Sultan-2 variety was 72.5 cm. The shortest among the studied varieties was Flip – 08-89. The height of the Sultan variety accepted as a standard was 57.5 cm. In general, erect forms of chickpea varieties should be preferred. The forms intended for the mechanical harvesting should not be prone to lodging.

One of the main parameters for cereal plants (especially chickpea and lentil) is the height of the first bean above the ground. Usually huge crop losses occur during harvesting due to a short distance between beans and the ground. The height of the first bean above the ground in the studied varieties ranged from 31.3 to 44.6. This parameter was the smallest (31.3 cm) in the short variety Flip-08-89. The largest value of this parameter (44.6 cm) was observed in the Nazrin variety, whereas for the tallest variety it was equal to 42.9. A significant positive correlation – $r=0.813^{**}$ was observed between plant height and the height of the first bean above the ground. The correlation among structural elements of the production was determined using the SPSS 16.1 program (Table 4).

The number of beans per plant in the studied varieties ranged from 15.3 to 48.6. The largest number of beans was observed in the Narmin variety-48.6, the smallest number was found in the Flip-08-89 variety-15.3. In the high productive variety Sechma L. the number of beans per plant was 47.4 and in the tall Sultan-2 variety-28.3.

One of the main purposes of the modern selectionists is increasing the number of beans and grains per plant. The number of grains per plant changed from 15.6 to 55.5 in the studied varieties. The number of grains per plant for the high productive Sechma L. variety was found to be 55.5 and for the low productive Sanford variety -21.4. It should be noted that a significant positive correlation was established between the number of grains and beans per plant ($r=0.986^{**}$). Moreover, a positive correlation was also established among the number of grains per plant, the number of beans per plant and productivity.

100-grain mass of the studied chickpea genotypes ranged from 32.5 to 44.9 grams. The Flip-08-196 variety is distinguished by grain size, 100-grain mass was found to be 44.9 grams. Tiny grains were observed in the high productive Narmin variety. In the Sultan variety accepted as a standard 100-grain mass was equal to 35.4 grams. A negative correlation was found between 100-grain mass and the number of beans (r=-0.354).

Production index (index of economic suitability) characterizes the distribution of assimilates formed during photosynthesis between generative and vegetative organs. Productivity of agricultural plants can be significantly increased by enhancing productivity index, which is determined as the ratio of grain dry biomass to total dry biomass (Bezmenova M.F., 2010). Production index ranges from 0.1 to 0.8 depending on the cultivation conditions of various plants (Yordonov et al., 2003). The increase in the productivity of modern varieties occurs at the expense of enhanced production index as a result of redistribution of assimilates using genetic-selection methods (Kursanov A.L. 1976). Optimum distribution of photosynthetic active radiation increases total biomass leading to a significant decrease in production index (Nichiporovich A.A. 1956). But application of mineral fertilizers creates favorable conditions to increase production index. Therefore, the enhancement of production index is considered to be one of the important directions in the modern selection for developing intensive type varieties.

Production index of the studied chickpea varieties ranged from 0.35 to 0.46. Production index of the high productive and low productive Sechma L. and Flip-08-89 varieties were 0.46 and 0.35, respectively. It suggests that in the Sechma L. variety more photosynthetic assimilates are transferred to the generative organs compared with other varieties. Productivity of the studied varieties ranged from 13.9 to 28.5 cwt/ha.

Table 4. Correlation among structural elements of the production in chickpea varieties.

	PH	B1	BN	GN	HGM	PI	GY
PH	1						
B1	0.813^{**}	1					
BN	0.618	0.174	1				
GN	0.556	0.093	0.986^{**}	1			
HGN	0.008	0.042	-0.354	-0.394	1		
PI	0.398	-0.044	0.703^{*}	0.744^{*}	-0.250	1	
GY	0.547	0.378	0.434	0.412	-0.456	0.410	1

** - correlation is significant at the 0.01 level.
* - correlation is significant at the 0.05 level.
Note: PH – plant height, B1 – height of the first bean above the ground, BN – bean number per plant, GN– grain number per plant, HGM – 100-grain mass, PI – production index, GY – grain yield

Table 5. Structual elements of the production in lentil varieties.

No	Variety	Plant height, (cm)	Height of the first bean above the ground, (cm)	Number of beans	Number of grains per plant	100-grain mass (g)	Production index	Productivity, (cwt/ha)
1	F-2014-009	32.9±3.5	18.3±1.5	39.4±2.1	53.9±4.0	7.4	0.41	16.0
2	F-2012-18	34.4±1.0	18.7±1.2	38.4±3.4	42.4±2.4	7.5	0.44	15.0
3	F-2013-29	37.5±2.7	20.4±2.3	26.3±2.0	28.5±2.1	7.6	0.32	14.0
4	F-2012-1L.	37.7±2.4	20.8±1.4	30.8±3.3	31.2±2.1	6.7	0.29	13.5
5	F-2014-006	36.9±2.2	20.9±2.6	27.3±2.1	27.8±1.3	8.0	0.36	13.1
6	Surian Local L.	37.8±2.0	21.3±1.0	47.1±3.3	50.3±2.7	6.8	0.26	12.5
7	F-2013-26	35.5±1.2	19.9±1.7	39.2±1.7	39.8±2.6	7.7	0.40	11.8
8	F-2012-8	41.9±2.4	25.0±0.9	37.1±4.1	52.8±3.8	6.7	0.27	11.3
9	F-2013-4	37.9±2.3	20.7±2.3	36.1±2.0	38.7±2.2	8.4	0.27	11.0
10	Arzu (st)	38.1±2.7	21.2±0.1	19.3±2.8	21.8±1.8	7.5	0.33	12.6

Table 6. Correlation among structural elements of the production in lentil varieties.

	PH	B1	BN	GN	HGM	PI	GY
PH	1						
B1	0.931**	1					
BN	-0.249	-0.066	1				
GN	-0.156	0.128	0.887**	1			
HGN	-0.349	-0.439	-0.317	-0.414	1		
PI	-0.788**	-0.715*	0.004	0.005	0.337	1	
GY	-0.715*	-0.625	-0.026	0.104	0.069	0.616	1

** - correlation is significant at the 0.01 level.
* - correlation is significant at the 0.05 level.
Note: designations as in Table 4

The highest variety among the studied ones appeared to be Filip-2012-8 (41.9 cm).

The height of the first bean above the ground ranged from 18.3 cm to 25.0 cm. The largest value of this parameter was observed in Filip-2012-8 (25.0 cm). As seen in Table 6 a significant positive correlation was detected between the height of the first bean above the ground and plant height (r=0.931**) in the lentil varieties. The number of beans per plant ranged from 19.3 to 47.1. The largest number of beans (47.1) was found in the Surian Local L. variety.The lentil varieties differ very much in the number of grains per plant. In the high productive Flip-2014-009 variety the number of grains per plant was found to be 53.9, whereas in the Arzu variety accepted as a standard this parameter was 21.8. As seen in Table 6 a significant positive correlation (r=0.887**) exists between the number of grains per plant and the number of beans.

In the studied lentil varieties 100-grain mass ranged from 6.7 to 8.4 grams. The largest parameter was observed in the Flip-2013-4 variety and in the Arzu variety accepted as a standard this value was equal to 7.5 grams.

Another main parameter of plant productivity is production index. In the lentil varieties this parameter varied over a wide range (0.26-0.44). Varieties with high production index were more productive.

Positive correlations were observed between production index and productivity in both chickpea and lentil varieties (r=0.410 for chickpea and r=0.616 for lentil varieties).

Thus, it is recommended to use the chickpea varieties F-08-89, Sechma L. and lentil varieties F-2013-18, F-2014-006 for developing drought tolerant forms. Parameters, such as the height of the first bean above the ground and productivity index can also be used in developing drought tolerant varieties.

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Noxud və Mərciməyin Quraqlığa Davamlılığının Təyin Edilməsi və Nümunələrin Məhsulunun Struktur Elementləri

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AR KTN Əkinçilik Elmi Tədqiqat İnstitutunun Bitki fiziologiyası və biotexnologiya şöbəsi

Məqalədə noxud və mərcimək nümunlərinin sahə şəraitində yarpaqlarının su saxlama qabiliyyəti, əkin səthinin temperaturu və məhsulun struktur elementləri haqqında məlumatlar əks olunmuşdur. Məlum olmuşdur ki, noxud nümunələrində məhsuldarlıqla paxlalıların sayı və bir bitkidə olan dənlərin sayları arasında birbaşa müsbət əlaqə mövcuddur. Mərcimək bitkisi üçün isə bir bitkidə olan dənlərin sayı ilə məhsuldarlıq arasında müsbət əlaqə aşkar olunmuşdur. Tədqiqat nəticəsində nisbətən quraqlığa davamlı nümunələr seçilmişdir.

Açar sözlər: *Noxud, mərcimək, yarpağın su saxlama qabiliyyəti, məhsul indeksi, məhsuldarlıq*

Определение Засухоустойчивости и Элементов Структуры Урожая у Сортов Нута и Чечевицы

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В статье приведены сведения о водоудерживающей способности листьев и температуре поверхности посева в полевых условиях у образцов нута и чечевицы, а также определены элементы структуры урожая. У образцов нута выявлена положительная связь между продуктивностью и числом зерен в бобах и числом зерен с одного растения. Обнаружена также положительная корреляция между продуктивностью и числом зерен с одного растения у образцов чечевицы. В исследованиях выявлены относительно засухоустойчивые образцы.

Ключевые слова: *Нут, чечевица, водоудерживающая способность листа, индекс урожайности, урожайность.*